Death of life sciences a personal perspective

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ABSTRACT

Increasingly our environment is impacted by anthropogenic activities, yet the study of whole animal biology is a neglected field of education together with a lack of support for systematic biology. The consequences of this lack of instruction and the environmental awareness it engenders is discussed both for the current and future generations of students. Suggestions are given as to how to reverse this situation and to change the attitude of academics responsible for developing course work to include the study of whole animal biology and systematics and the importance of senior scientists mentoring the next generation.

Key words: invertebrates, undergraduate teaching, whole animal biology

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Introduction

An earlier RZS publication explored our lack of knowledge about Australia's invertebrate diversity (Ponder and Lunney 1999). This has not changed since that publication. So what are the consequences of our lack of knowledge of invertebrate diversity? Firstly, one must consider the role which invertebrates play in marine and terrestrial ecosystems. Invertebrates are central to the functioning of all ecosystems; the breakdown and recycling of organic matter, bioturbating sediments and soils, providing food for other organisms, as well as being important as pollinators, predators, and parasites (Ponder *et al.* 2002).

While it would be ideal to have scientific names for all of our invertebrate fauna this is not a realistic given levels of funding and staff. Of more importance for invertebrate conservation is answering the ecological questions that should form the basis of management strategies. For example, which habitats are most diverse? How do invertebrate assemblages change over time and space? What are the appropriate sized areas for their conservation and the level of connectivity which is obviously related to how far do invertebrate populations disperse? In fact similar questions are also relevant for vertebrate populations and even though we know more about these animals we still struggle to answer the above questions concerning appropriate management strategies which should be implemented.

A good example of a study where changes in abundances of the diverse arthropod communities of eucalypt forests could be related to seasonal factors such as leaf production, and rainfall patterns was by Recher *et al.* (1996). They also showed that variability between years can be as great as between seasons. Recher *et al.* were able to explain this variation by classifying the fauna into functional groups, for example herbivorous groups responded to leaf production whereas decomposers and fungus feeders were stimulated by higher moisture availability. Other studies by this group (Majer *et al.* 2003) examined the species composition of bark fauna and found significant turnover in species composition over distances of just 10 km or perhaps even less as they only sampled at distances of 10 km which raises important questions as to how conserve these eucalypt forests. While obviously the diversity of these arthropods is interesting especially to the relevant entomologist, the consequences of these changes is critically important for the variety of wildlife which are dependent on these invertebrates, as well as for managing the remaining eucalypt forests especially in areas where extensive clearing has already taken place. How large do remaining stands need to be to be of conservation value for example? These studies were of necessity limited in time and place but highlight the need for far more studies to be carried out if we are to evaluate the impact of disturbance on forest communities (Majer *et al.* 1997, 2006). Managing these forests and their associated conspicuous vertebrate fauna such as arboreal marsupials and the birds without considering their invertebrate fauna on which they feed upon may lead to inappropriate management plans and actions.

We will never be able to manage invertebrate faunas to the same degree as we attempt to manage vertebrates except perhaps for a few iconic species. So realistically we should use our resources to answering broad ecological questions and how these invertebrate faunas respond to environmental factors and therefore how this will affect the functioning of all ecosystems, and how they are responding to climate change.

Another issue which needs to be urgently addressed is amongst conservation authorities etc. that conserving invertebrate faunas, even without knowing what species are out there or where they occur, is ethically responsible and environmentally sane. That is conserving biodiversity is more than just managing the megacharismatic whales and dugongs. This requires that those managers are exposed to

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whole animal biology during their undergraduate and graduate training and reinforcing what also should be being taught at school. However we know this is either not occurring, or only rarely. Similar comments are made by botanists (Adam 2010).

If we do not know the major components of communities, then how can we effectively manage them? Also in addition how can we monitor these communities to determine if our management strategies are actually working? Or do we hide under the conception that by managing habitats by default we are are managing all the components, i.e. the use of surrogacy which certainly still needs a lot of testing in the marine environment (Ramey and Snelgove 2003; Magni *et al.* 2006).

So my concern is that when students finish their undergraduate degree they have little knowledge about the major groups of animals, that is, the invertebrates, how to even identify them to major groups so as to be able to search for information on their life styles, habits etc. Do they have any appreciation of the tremendous diversity of invertebrates? Without this basic information or admiration for these animals how will the next generation of field biologist be able to detect how communities are changing in response to climate change, impacts of increasing urbanisation and fragmentation and species invasions? If they cannot recognise the major components of the fauna what are the consequences of this? For example if there is a loss of bird and conspicuous mammal species, is this related to declining invertebrate populations upon which they feed? Or other factors involved? Another example could be: are the benthic communities on the mudflat changing and how is this impacting on the nursery grounds for our commercial fish and crustaceans? We need to actually sample these invertebrate communities and as shown by the work of Majer and Recher identifying them to species may not critical and just describing them as morphospecies may be sufficient to detect changes in community structure over time. But hopefully the material collected during such studies is deposited in a museum for subsequent full identification. But first of all there needs to be an acknowledgment of the importance of these invertebrate communities in both terrestrial and marine ecosystems and their interactions with the vertebrates. Another important question in the marine environment is that over 250 invasive species have been recognized in Australian waters primarily in ports and estuaries and while some of these become pests ((http://www.marinepests.gov.au/) and have been investigated, many others appear to be benign but do we really know, the answer is no. But a major problem is the lack of expertise necessary to recognise an invasive species from either a described Australian species or as yet an undescribed native species.

I would suggest that these graduates will not be inspired to ask the above sorts of questions in part because they have not being exposed to live animals either in practicals or in field courses, rather they learn about processes and systems rather than studying the major components of ecosystems i.e. the animals! Certainly when they do see live animals they do marvel at their beauty, and begin to think about the roles they play, but this to be reinforced on a regular basis.

Is this just my misconception or the stark reality? While I do not teach on a regular basis at any University I do give the occasional guest lecture and also I do supervise students from many Australian universities from both undergraduate to postgraduate level, as well as students from several overseas institutions. I find it very worrying that most of these Australian students have a very limited knowledge of even the major invertebrate groups, in terms not only of their basic body plans but of their life styles, ie where do they occur, what do they do in terms of reproductive and feeding habits and even less about how one identifies them even to major groups. Mention some of the smaller phyla and these students look blank. Often an introductory invertebrate course covers all the major groups in a single semester an impossible task.

So I checked out the websites for each of the universities in Sydney and explored the undergraduate courses on offer although navigating through the various websites, although it was a bit of a nightmare. The University of Sydney next year will run a single course called Zoology in second year and this will replace the courses previously run (Invertebrate Zoology, Vertebrates and their Origins, and Entomology) and it appears it will be more function than diversity based. As well as losing a course which at least discussed the major invertebrate groups, the special projects whereby second year students worked at The Australian Museum and Taronga Park Zoo and undertook a small research program and produced a literature review and poster outlining their research has been abandoned. Over the years I have had students exploring polychaete diversity on mud flats, or rocky shores, other examined their morphology using the SEM. Virtually all museum researchers were involved in these student projects and also importantly they were exposed to the large collections of animals housed in the museum especially the invertebrates. Checking the website I can see no other courses dedicated to invertebrates during first or third year, although students studying marine ecology will be exposed to some invertebrates but not from a systematic point of view, rather an ecological point of view.

At the University of New South Wales, they offer a course on invertebrate diversity emphasising their evolution, morphology, behaviour, and relationships to marine, freshwater and terrestrial environments. Invertebrate conservation and applied aspects of invertebrate biology are included. Practical work includes examining living and preserved specimens (including dissections) in the laboratory and the field, and techniques for invertebrate identification according to the University handbook. This course is given in second year and involves 26 lectures, 12 practicals and a 2 day field. As the course co-ordinator explained to me, he hopes to inspire the students as to the value of invertebrates and potentially why it is often necessary to identify animals to species and the significance of a name. But it is not until they do Honours or begin a PhD when they actually have their own samples that they really are faced with the need to formally identify species. This has led to some researchers organising in house workshops, a recent one on bryozoans was held UNSW for students working on fouling plates and needing to separate native from introduced species.

Checking out the website for the University of Technology Sydney yielded no courses being offered in either Invertebrate Zoology or Zoology. Instead they offer a Bachelor of Science in Marine Biology – "which focuses on how the marine environment works and how it can be better managed. This requires a thorough understanding of the way plants, animals and micro-organisms function in marine ecosystems (including estuarine, coastal, oceanic and coral reef ecosystems and Antarctica), as well as the skills required to detect and assess detrimental impacts on these marine environments resulting from anthropogenic sources and climate change" according to the handbook. They also offer a Bachelor of Science (Honours) in Environmental Sciences and this honours course offers training in research and introduces advanced areas of study in a range of fields in environmental science including marine biology, environmental forensics and environmental biology, according to the website.

Macquarie University in the second year, a semester on Animal structure and function is given which includes two lectures and a practical per week. According to the handbook, "this unit explores biological diversity of form and function in the major groups of animals. Relationships between structure and function are emphasised using a comparative approach to understand how different animal groups carry out similar life processes. This unit also discusses how structural characteristics and their corresponding function have adapted to specific environments, with particular focus on adaptations that enabled life on land for various taxa. This unit is suitable for students interested in whole animal biology, science education and students interested in further research or research careers".

Macquarie University also offer third year offers a course called: Invertebrates: evolution behaviour and diversity. According to the handbook, "this unit explores the fascinating world of invertebrate animals. The unit starts by briefly outlining the features of the major groups of invertebrate animals (excluding unicellular organisms). Once this is established, we move away from a taxonomic focus to discuss major topics including: mating systems, communication, host-parasite relationships, predator-prey interactions, biological control, climate change, and conservation. These major topics draw on examples from research papers on various groups of invertebrates. This unit is suitable for students who are interested in whole animal biology or biological education, or for students who are interested in further research". So even allowing for these two courses this is still a cursory introduction to the diversity of invertebrates. I was able to confirm this lack of generalised knowledge of invertebrates recently after giving a lecture to 3rd year biology students on the phylogeny of the annelids. While they had little knowledge of this large invertebrate group some seemed quite captivated with the sheer diversity of annelids which I illustrated while discussing how we were beginning to understand how they were related to each other and to other invertebrate groups.

A slightly different approach on invertebrates is taken by the University of Western Sydney, and the handbook indicates that in the first year a course on biodiversity is given and the handbook describes this as, "how many species walk, fly, swim or slither, crawl, hop, wriggle or just float, hitchhike or move so slowly that they appear not to move at all? No one knows and new species appear almost every day. This unit focuses on this spectacular diversity of living things and the process of evolution. Students explore and classify biodiversity and how organisms function, acquire and assimilate resources and co-ordinate growth and reproduction. Organisms interact with one another and their environment forming a complex set of interactions in ecosystems. It is these interactions that have driven evolution. Ultimately human survival depends on the sustainable use of this biodiversity and ecosystems". I presume this course includes at least some mention of invertebrates. There appears to be no other courses given which could include invertebrates although there is a course given in third year regarding vertebrate diversity.

The above courses are for students taking a biology degree at one of the universities in Sydney, and I somehow doubt it differs in other cities. The situation is worse for those participating in environmental studies, where a lot of emphasis is given to the theoretical aspects of terrrestial and marine ecology with little time spent on the components of these ecosystems. Instead a lot of time is devoted to how to measure various physical and chemical parameters. Field exercises often involve collecting some biota and just identifying to phylum rather than trying to identify to species units. Basically these students who will largely go into consulting or government agencies managing our natural environments will have a very limited understanding of the majority of their fauna.

Talking to colleagues in these Departments, while concerned that traditional courses on invertebrates were no longer being offered, they suggested that this was a universal trend and was in part driven by the students who were concerned as to ensuring that they took courses which would facilitate them being employed at the end of their course. This seems to translate into courses on genetics and molecular studies, statistics etc being offered as well as ecological courses and ones dealing with environmental issues but at a fairly cursory level. Students it appears are no longer interested in curiosity driven science which is somewhat depressing. In many departments there are no longer staff who could actually teach such traditional courses. Obviously some lecturers do talk about invertebrates and there are options for Honours and PhD's involving whole animals but somewhere students need to be enthused- and stimulated to work on invertebrates rather than on the soft furry animals or the megacharismatic!! Because so much needs to be investigated on invertebrates not just their natural history, their ecology and their taxonomy. Probert (2010), in an editorial published in 'Aquatic Conservation: Marine and Freshwater Ecoystems', bemoans the decline of taxonomic studies and the need to strengthen taxonomic studies commensurate with the growth of biodiversity programs. While he focuses on the situation in New Zealand, his take-home message is equally valid here in Australia.

Many others have similar concerns, and Beehler (2010) discusses the role for natural history in the twenty first century. He advocates "that studying natural history merits taking its place as a formal and recognized field of academic study, and there should be no battle waged between those students that aspire to medical school and those who aspire to study nature". Pyle (2001) provides a rather depressing account of the rise and fall of Natural History, and his subtitle is "how a Science grew that eclipsed direct experience". He reinforces the need to foster a child's interest in natural history, and this is the outcome of curiosity and wonder – this needs to be fostered by high schools and universities. His final quote is that "it may be naturalists who save us in the end, by bringing us all back to earth".

This situation will only continue to deteriorate with successive generations of students. Yet often the reason students were attracted towards biology or environmental studies was a fascination in animals and a concern about environmental degradation and wanting to make a difference. Students, when actually exposed to live invertebrates, are often amazed at their diversity, beauty etc and most love field work where animals are actually collected, and live animals examined. Yet field courses are expensive, and increasingly OH&S issues make their running quite a mine field. especially any involving snorkelling and scuba diving is just off limits. Not only are field trips expensive, there is a lack of field stations in Australia where such trips can be held. In the USA, Europe and the UK summer teaching schools play an important part of undergraduate courses in exposing students to whole animal biology and natural history. Even before I went to University in the UK, I had been on two such summer schools, on one we explored the diversity of marine life along the coast of the south west coast of Wales, and on the other one we investigated populations of small mammals in southern Devon. Both of these I still remember vividly. While an undergraduate, in addition to field trips organised by my department, I participated in courses run by the Plymouth Marine Biological Association where students from all over the UK attended and again we were exposed to collecting and examining live animals. All these courses were run by staff whose research interests involved whole animal biology. Even at that stage I was beginning to learn how to identify species of polychaetes, in part helped by the availability of field guides, even though they were in French!

So how can this situation be reversed? Students need to be exposed to people actually work with invertebrates and have a broad knowledge of their group. This can be done through specialised workshops. For several years the University of Wollongong in conjunction with several mollusc workers at the Australian Museum has been runing intensive mollusc workshops which are open to any Australian student and they have been remarkable successful. Students are exposed to hearing from the relevant experts who can convey their enthusiasm for the group, examining live material and several of them have gone onto continuing their studies on molluscs. But even they do not continue to study molluscs, they will have some background knowledge of one of the major invertebrate groups which may be very relevant in their future careers. For several years I was involved in teaching coral reef biology courses at Heron Island, and I have met students, years after, who still remember those courses and were influenced by them. So I would contend that personal contacts are critical, obviously not everybody is a wonderful lecturer, but if talking to a small group of students can really convey their enthusiasm for a group which can be highly infectious. This may just be accounting their methods of reproduction, their diversity and distribution, or how molecular studies can confirm species identifications based on morphology or else reveal suites of cryptic species, or how current distributions of estuarine species can be explained by previous sealevels and drainage patterns of these estuaries. Field courses are an ideal way of encouraging this enthusiasm, and while most will not continue on with field studies, they have at least they will have been exposed to whole animals.

We need to see the reintroduction of whole animal biology at University and an acceptance that we must study the components of our ecosystem in order to manage it as anthropogenic impacts continue. This must be accompanied by people beginning to respect and value what is left of our biota, even in cities a surprising amount still remains (Lunney *et al.* 2010) and people can make a difference to this. Children need to be encouraged to look and see what is around them, not just recognising the bird species but marvelling at the insects and other invertebrates abounding in their gardens and parks. Without a respect for all these animals, we will continue to modify and damage our environment by a variety of anthropogenic activities and see entire ecosystems collapse with devastating consequences for all species and of course we are just one of those species!

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